Original Article

Effect of the Type of Endodontic Sealer on the Bond Strength Between Fiber Post and Root Wall Dentin

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Abstract

Objectives: An important factor that interferes with the bonding between the root canal wall and resin cement is the root canal sealer remnant. There is controversy about the effect of eugenol-containing sealers on the bond strength between resin cements and fiber post. The aim of this study was to evaluate the effect of the type of endodontic sealer on the bond strength of FRC posts cemented with resin cement to the root canal wall.

Materials and Methods: In this in vitro study, 20 extracted mandibular first premolars were endodontically treated and divided into two groups according to the endodontic sealer used (n=10): G1: AH_{26} (Resin based); and G2: Endofill (Eugenol-based). After preparing post space, adhesive resin cement (Panavia F 2.0) was used for cementation of the fiber post to the root canal dentin. Three 3 mm thick slices were obtained from each root.

The push-out test was performed with a cross-head speed of 1 mm/minute. Two-way ANOVA and Tukey post hoc tests were used for analyzing data (α=0.05).

Results: The two-way ANOVA showed that different root canal sealers ($P=0.037$) had significant effects on bond strength (BS), but root canal regions ($P=0.811$) and interaction between root canal sealers and root canal regions ($P=0.258$) had no significant effects on BS. Maximum and minimum mean values were observed in the AH_{26} group, the apical region and the Endofill group in the apical region, respectively. Post Hoc Tukey test revealed that there were no significant differences between different root canal regions in both cements ($P>0.05$).

Conclusion: The region of root canal had no effect on the bond strength of cemented fiber posts to the root canal. Eugenol-based sealers (Endofill) significantly reduced the bond strength between fiber posts luted with resin cement to the root canal.

Key Words: Resin Cements; Dental Bonding; Zinc Oxide-Eugenol Cement

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INTRODUCTION

Intra-radicular posts are used to provide retention for restoration of the coronal structure of endodontically treated teeth [1-7].

In the recent years, the fiber reinforced composite (FRC) posts have become more popular because of their suitable physical characteristics that are similar to tooth structure [8, 9].

The FRC posts are cemented in root canal space using different resin cements [3]. The overall retention of FRC posts in the root canal depends on the bond strength between different parts of the combined ‘sandwich’ post-cement-dentin assembly [10-13]. Many of the fiber post failures occur between the root canal wall and adhesive resin cement [14, 15]. So, understanding the factors that interfere with the bonding between the root canal wall and resin cement is important [16]. One of these interfering factors is the root canal sealer remnant [17]. The zinc oxide-eugenol-based sealers have the widest use today. These sealers can collect free radicals that disturb the polymerization reaction of resin cements [18]. It has been claimed that this can decrease the bond strength between the FRC post and root canal dentin [2, 15, 18-20].

However, other researchers have reported that eugenol-containing sealers do not have any significant reduction in the adhesion between cemented FRC post with resin cement to the root wall [18, 21-26]. The aim of this study was to evaluate the effect of the type of endodontic sealer on the bond strength of FRC posts cemented with resin cement to the root wall dentin. The null hypothesis investigated was that the bond strength of FRC posts cemented with resin cement in the presence of different endodontic sealers is not significantly different.

MATERIALS AND METHODS

In this in vitro study, 20 extracted human mandibular first premolars were selected.

A total sample size of 20 (at least 10 per group) was required to detect a difference of at least 80% between any two groups with a power of 84% at a 5% significance level. The selected teeth did not have any caries, cracks or fractures, resorption, open apex or previous root canal treatments.

The teeth were cleaned of calculus or soft tissue remnants and were placed for two hours in 2.5% *NaOCl* (Golrang, Golrang co., Tehran, Iran) and then stored in 0.1% NaN_3 solution.

Diamond discs (Ref.070, *D&Z*, Berlin, Germany) mounted in a dental lathe machine (*KaVo* Polishing Unit. *EWL* 80, Germany) were used at low speed under constant water irrigation for removing teeth crowns to achieve a 15-mm root length. Barbed broaches (Dentsply/Maillefer, Ballaigues, Switzerland) were used to remove pulp tissues. The same operator performed canal instrumentation using the step-back technique (1-mm short of the apical foramen). The master apical file was the number 35 K-file (Dentsply/Maillefer, Switzerland).

During canal preparation stages, the canals were irrigated with 5.25% sodium hypochlorite solution (Golrang, Iran).

Finally, paper points were used to dry the root canals (Aria dent, Asia Chemi Teb Co, Tehran, Iran).

The roots were randomly divided into two groups of 10 specimens each (Table 1). In each group, obturation was performed by the vertical condensation method using one type of root canal sealers (Table 1) and gutta-percha (Aria dent, Tehran, Iran).

Table 1. Root Canal Sealers Used in This Study

Root Canal Type	Trade Mark	Manufacturer
Resin-Based	AH_{26}	Dentsply Caulk, Milford, Germany
Eugenol-Based	Endofill	Dentsply, Indústria e Comércio Ltda., Petrópolis, RJ, Brazil

Provisional restorative material (GC Caviton; GC Dental Products Corp., Tokyo, Japan) was used to fill the coronal root canal orifices and the teeth were stored for one week in 100% humidity at 37°C to ensure the setting of the used root canal sealers.

Then, coronal gutta-percha of each root was removed to a depth of 10-mm with a Gates Glidden drill *#3* (Dentsply/Maillefer, Switzerland) and 4-mm gutta-percha was preserved in their apices. All post spaces were prepared to a *No*. 3 post drill (Fibio, Anthogyr, Sallanches, France). Finally, the canals were irrigated with distilled water and dried with paper points (Aria dent, Tehran, Iran).

For post length and diameter similarity, a glass reinforced fiber post size #3 (Hetco fiber post, Hakim Toos, Mashhad, Iran) was tried in the post spaces and then all posts were cut to the length of 10-mm from their apex with diamond discs (Ref.070, D&Z) mounted in a dental lathe machine (*KaVo* Polishing Unit, *KaVo EWL*) under water irrigation. In all groups, the shortened posts were cleaned with 70% ethanol for 60s, rinsed with distilled water and air-dried.

According to a previous study (6), the posts were immersed in 20% H_2O_2 for 20 minutes at room temperature. The posts were rinsed with running water for 2 minutes. After air-drying, the post surfaces were painted with a single layer of a silane coupling agent (Ultradent® Porcelain Etch and Silane, Ultradent Products Inc., UT, USA) for 60s and dried for 60s with gentle air stream.

In all groups, the root canal walls were conditioned with an autopolymerizing primer (ED-primer, Kuraray Medical Inc., Tokyo, Japan) for 60s. Then, the post spaces were air-dried and the excess primer was removed with paper points (Aria dent, Iran). In the cementation stage, equal amounts of base and catalyst pastes of an adhesive composite resin cement (Panavia F2.0, Kuraray Medical Inc., Tokyo, Japan) were mixed and applied on the prepared post surfaces and into the post spaces with a lentulo spiral instrument (Dentsply/ Maillefer, Switzerland). The fiber posts were inserted into the root canals using gentle finger pressure. After removing the excess cement around the post, oxygen-inhibiting gel (Oxyguard II, Kuraray Medical Inc. Tokyo, Japan) was used to protect the remaining cement. The resin cement was light cured for 60s by a halogen light unit with 500-mW/cm2 intensity (Coltolux50, Coltene, Altstatten, Switzerland). Before each light exposure, Coltolux light meter (Coltene, Altstatten, Switzerland) was used for monitoring accurate light intensity of the light output.

After storing all specimens in 37°C saline for one week, all the specimens were subjected to thermocycling treatment for 5000 cycles at temperatures alternating between 5 and 55°C for 30s each with an intermediate pause of 15 seconds.

Each dental root was sectioned perpendicular to its long axis using a diamond disc (Ref.070, *D&Z*, Germany) mounted in a cutting machine (TL-3000, Vafaei Industrial, Tehran, Iran) at low speed under water irrigation to create three post/dentin slices (coronal, middle and apical) with 3-mm thickness for each slice. Due to using tapered fiber posts, the post diameters and each slice size were measured using a digital caliper (Mitutoyo digital caliper 500-714-10, Mitutoyo Co, Tokyo, Japan) with 0.01 mm accuracy.

Push out test was performed with a universal testing machine (Walt+Bai AG Testing Machines Industries trass 4, Löhningen, Switzerland) at across head speed of 1 mm/min. The push-out pin was placed on the center of the apical end of the sliced fiber post and in an apico-coronal direction without inserting extra forces on the surrounding root canal walls. Therefore, it was necessary to make three push-out pins in three diameters (0.7, 0.9 and 1.0 mm) that were used for each three-root section, respectively (apical, middle and coronal parts). The peak force (*N*) required to extrude the fiber post from each root slice was recorded for all specimens. The bond strength in *MPa* was calculated with the following formula:

$$A = \pi(r_1 + r_2)\sqrt{(r_1 - r_2)^2 + h^2}$$

In this formula, π is the constant 3.14, r_1 is the coronal post radius, r_2 is the apical post radius and *h* is the slice thickness in mm.
The data were analyzed (*SPSS/PC*16.0; *SPSS* Inc., Chicago, Ill) using two-way ANOVA and Post Hoc Tukey test at $P<0.05$ level of significance.

RESULTS

Table 2 shows the mean tensile bond strength (TBS) and standard deviation (SD) values for all experimental groups in different root canal regions.
The two-way ANOVA showed that root canal sealer as a main factor (P=0.037) had significant effect on BS, but root canal dentin regions (P=0.811) and the interaction between root canal sealers and root canal regions (P=0.258) had no significant effects on BS (Table 3). The AH_{26} had the highest TBS mean value especially in the apical region. The lowest TBS mean value was seen in the Endofill group and in the apical region. Post Hoc Tukey test revealed that there were no significant differences between different root canal regions in both groups (P>0.05) (Table 4).

DISCUSSION

The results of this investigation rejected the null hypothesis that different endodontic sealers do not have any effect on the bond strength of FRC posts cemented with resin cement.

Table 2. Descriptive Statistics and Mean TBS (MPa) and SDs for Study Groups (n=10)

Cement	Region	Mean	Std. Deviation	95% Confidence Interval	
				Lower Bound	Lower Bound
Endofill	Coronal	2.41	.90	1.54	1.54
	Middle	1.79	1.03	.92	.92
	Apical	1.74	1.41	.88	.88
AH_{26}	Coronal	2.41	1.24	1.55	1.55
	Middle	2.61	1.73	1.74	1.74
	Apical	3.18	1.65	2.32	2.32

Table 3. Two-way ANOVA Results on the Effects of Surface Treatments, Root Canal Regions and Their Interaction on the TBS

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	14.50[a]	5	2.90	1.55	.18
Intercept	334.52	1	334.52	179.60	.00
Cement	8.53	1	8.53	4.58	.03
Region	.78	2	.39	.21	.81
Cement * Region	5.18	2	2.59	1.39	.25
Error	100.58	54	1.86		
Total	449.60	60			
Corrected Total	115.08	59			

a. R Squared = .126 (Adjusted R Squared = .045)

According to the present study, the mean tensile bond strength (TBS) of fiber posts that were luted in the root canals with resin based sealer (AH_{26}) was significantly higher than those luted with eugenol containing sealer (Endofill). Other studies have also showed that eugenol containing root canal sealers can decrease the bond strength of resin cements [1-3, 16, 18-20, 27]. It has been mentioned that eugenol (2- methoxy-4-allyphenol) can spread in dentinal tubules and its phenolic components can deactivate the molecules in the growing polymer chains and jeopardize resin cement setting and decrease the bond strength [1, 3].

However, other studies did not find any statistically significant difference between different types of root canal sealer on the retention of glass fiber posts using resin cements [21, 22, 24, 25, 28]. On the other hand, a greater amount of eugenol is released during the first two weeks of using eugenol containing sealer [18]. In the present study, post cementation was performed one week after completing endodontic treatment. So the remnants of the eugenol containing sealer could interfere with the polymerization reaction of resin cement and decrease its bond strength.

However, some authors reported that there are no differences between effects of various root canal sealers on the tensile bond strength of fiber posts [21-26, 28].

It is stated that during post space preparation, most of the root canal sealer remnants are removed and the amount of debris and free eugenol available to inhibit the polymerization reaction of the resin cement is decreased.

Therefore, creating a clean post space is one of the most important factors in achieving bonding with resin cements [28].

Another technique for cleaning the post space wall is phosphoric acid etching followed by water rinsing [11, 29].

Self-etching systems that eliminate etching, rinsing, and drying steps may decrease the bond strength of self-etching systems due to incomplete cleaning of the root canal space [30, 31].

The resin cement system used in this study has a self-etching bonding system (ED primer) that is less aggressive than etching with 37% phosphoric acid [29, 32].

So the created thick smear layer in the post space might decrease the bond strength of the used resin cement in this study.

Table 4. Post Hoc Test (Tukey's HSD) for Comparing All Test Groups

	(I) Region	**(J) Region**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
						Lower Bound	**Upper Bound**
Tukey HSD	**Coronal**	Middle	.21	.431	.87	-.82	1.25
		Apical	-.05	.431	.99	-1.09	.98
	Middle	Coronal	-.21	.431	.87	-1.25	.82
		Apical	-.26	.431	.81	-1.30	.77
	Apical	Coronal	.05	.431	.99	-.98	1.09
		Middle	.26	.431	.81	-.77	1.30

Based on observed means.
The error term is Mean Square (Error) = 1.863.

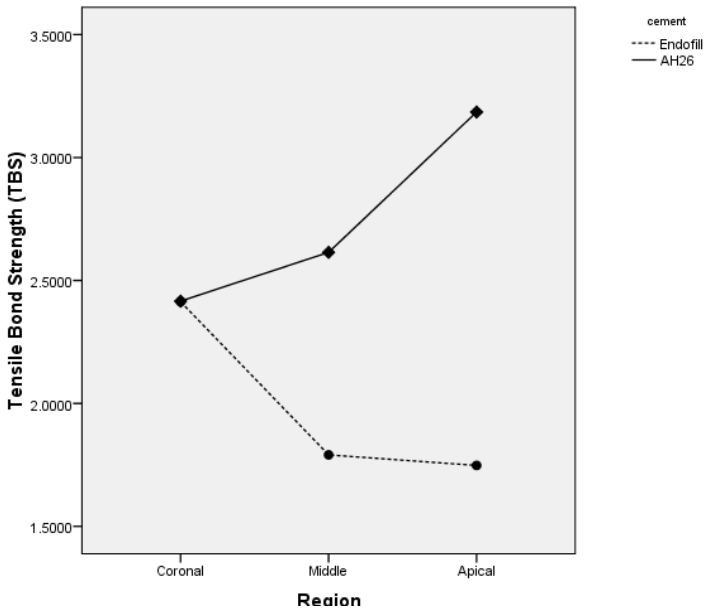

Fig 1. Results for tensile bond strength in all experimental groups

Bond strength of resin cement can be at the highest level if the orifices of dentinal tubules are kept open [2], but eugenol can spread in these tubules and modify the surface of the cement resin and decrease bond strength [3]. It has been showed that using alcohol or acid conditioning in the post space can increase bond strength [32]. The self-etching system (ED-primer) that was used in this study did not condition the post space wall and the lower bond strength of the Endofill group and decreasing the bond strength from the coronal to apical region in this group can be explained by this fact. It is interesting that in AH_{26} group (resin based sealer) the bond strength was increased in more apical regions (Figure 1).

This can be due to lower penetration of the resin sealer into dentinal tubules or the presence of residues of resin based sealer in the apical portion of post space. These residues can bond with post space walls and may help better bonding with resin cement.

This finding is in accordance with studies [33, 34] that used resin cements and resin based sealers and found highest push out strengths in the apical sections.

Therefore, resin based sealers can be used in the inaccessible apical site within the root canal space; thereby creating strong bonding strength as well as a fluid-tight seal [34]. Jha [33] imputed a greater bond strength in the apical third to factors such as the greater wear of this region by endodontic reamers and creating a clean dentin that comes in better contact with the bonding agents. In addition,, he stated that there is an intimate contact between the post and root canal wall in this area, while the misfit between post and root canal space in the coronal region results in a greater volume of resin cement that can increase stress in the cement layer due to polymerization shrinkage.

Moreover, because the cement layer is the weakest area between the post and the post space wall, the greater thickness of the cement may be the cause of the reduced bonding strength observed in the coronal third [14]. Although these argumentations can explain the higher bonding strength in the apical third of specimens in the AH_{26} group, they cannot clarify the opposite condition in the Endofill group.

In the Endofill group, our results are in accordance with studies that have reported higher bonding strength in the more coronal thirds [5, 11, 35].

The higher tubular density and diameter of the coronal third of the post space are more than the other regions. Furthermore, the dentinal hybridization is not uniform and lateral branches of resin tags are not seen in the apical thirds of post space [36]. Furthermore, more access to the coronal third of the canal makes etching and applying the adhesive agents [36, 37] and direct light transmission to canal walls [36] more effective in this area. However, Aksornmuang *et al.* [35] found no significant differences in the bond strengths among different regions of the root canal walls.

They related this result to this fact that their used light source had a light intensity of about 90±3 mW/cm2, which was not enough to completely cure composite resin. The present study had some limitations. For example, the specimens had no coronal tooth structure, only one type of fiber post and adhesive were evaluated and the influences of fatigue loading on the push out TBS of specimens were not investigated.

In vitro tensile tests for measuring bond strength may not be exactly representative of the clinical conditions. Therefore, clinical studies should be performed to validate the results of the present study.

CONCLUSION

Within the limitation of this in vitro study it was concluded that:

1. The type of root canal sealer had significant effect on the bond strength of cemented fiber posts.
2. Eugenol-based sealers (Endofill) significantly reduced the bond strength of fiber posts luted with resin cement.
3. There were no significant differences between different root canal regions in both groups.

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